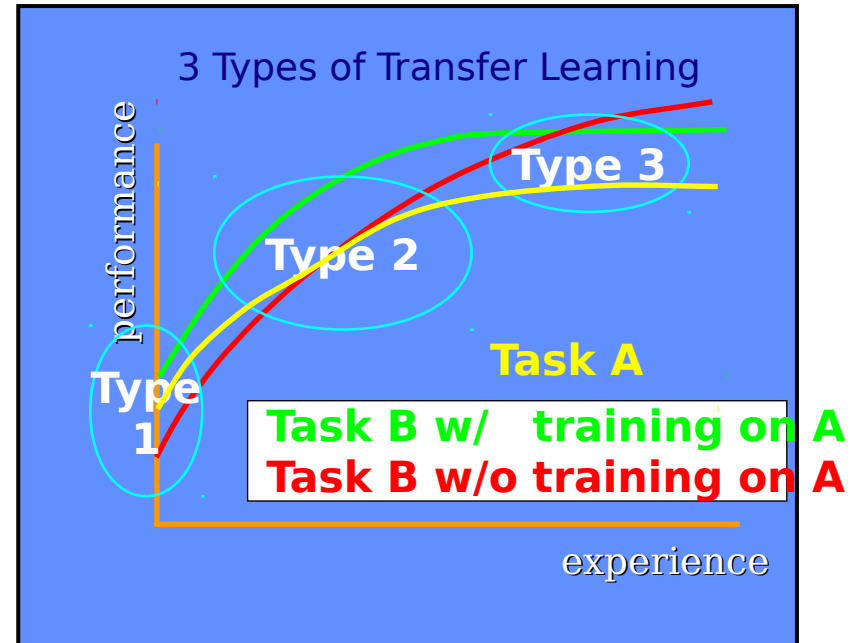


Transfer Learning

Program Briefing



Information Processing Technology Office
Defense Advanced Research Projects

Distribution Statement A - Approved for Public Release, Distribution Unlimited Agency

Motivation: Military Needs

- **Adapt rapidly to new situations**
 - Sensor systems:
 - Target recognition systems need to adapt quickly to new target types, new background/atmospheric conditions, new sensor hardware
 - IED detection systems need to adapt quickly to new IED and camouflage types
 - Control systems:
 - UAV controllers need to adapt quickly to new payloads, damaged control and lift surfaces
 - AGV controllers need to adapt quickly to new terrain types, road surfaces, obstacle/vegetation types, etc.
 - Decision (support) systems:
 - Tactical and strategic planning systems must adapt quickly to novel enemy behavior, new weapon systems, new terrain factors, etc., without having to relearn all levels of behavior from scratch
- **Take advantage of totality of training data from diverse populations while avoiding overfitting to unique characteristics**

“... What you have here is not a static situation, you have a dynamic situation with an enemy that thinks, uses their brain, constantly adjusts, and therefore our commanders have to constantly make tactical adjustments”

- from an interview with
Secretary Rumsfeld, 7 April 2006

Program Goals and Structure

- **Program Goals:**

- Transform focus of machine learning research and capability of ML software from “performance improvement on same/similar tasks” to “take advantage of previous experience in novel situations”
 - Motivated by how people learn and use learned knowledge, skills, abilities
- Develop general capabilities useful in many domains, to enable wide-range of military applications that need this capability
- 10 “transfer levels” capture similarity/difference between source and target domains

- **Program Structure:**

- Two large technology development teams
 - Each proposed their own domains, metrics, Go/NoGo criteria, etc.; ≥ 3 per team
 - Distinct approaches
 - Evaluate technologies in at least 3 domains
- One evaluation team
 - Internal and external domains
 - Support Go/No-Go decisions
 - Leverage beyond funded research

Shift Focus of Learning Research

Herb Simon defined learning as:

*“Any change in a system that allows it to perform better the second time on repetition of the same task or on another task **drawn from the same distribution.**” (1983)*

THIS HAS BEEN THE PREDOMINANT TASK OF MACHINE LEARNING RESEARCH
IN CONTRAST, PEOPLE USE WHAT THEY HAVE LEARNED FROM PREVIOUS
EXPERIENCES TO PERFORM WELL IN NOVEL SITUATIONS
WE WILL SHIFT THE FOCUS OF MACHINE LEARNING RESEARCHERS
TO WHAT PEOPLE DO:

Transfer Learning:

The ability of a system to recognize and apply knowledge and skills learned in previous tasks to novel tasks (in new domains)

THIS IS IMPORTANT NOT ONLY AS PART OF OUR COGNITIVE SYSTEMS AGENDA, BUT ALSO BECAUSE FUTURE MILITARY MISSIONS WILL INVOLVE NOVEL SITUATIONS, AND WE MUST GET THEM RIGHT THE FIRST TIME

Levels of Transfer

Strategy Games

Physics (Mechanics)

Train on turn-based game
Test on real-time game

10. Differing

Apply learning from other courses;

Train on one real-time game

9. Reformulating

Learn use of Newtonian eqns,

Test on another location
Train w/ deception only for location

8. Generalizing

apply Hamiltonian eqns
Learn conservation of momentum, apply conserv. to other quantities

Test w/ deception for loc & weapons
Vary weapons and weapons

7. Abstracting

Train on momentum problems,

Train w/ foot or mounted soldiers

6. Composing

test on angular momentum
Combine knowledge about rotational motion & momentum

Test with both
Vary map

5. Restyling

Train on one textbook's formulation,

Vary number of friendly/enemy units

4. Extending

test on another's formulation
Same components, but more of them

Vary non-combatants on map

3. Restructuring

Same formulas, different variables, or same components, different configs

Change composition of friendly and/or enemy units

2. Extrapolating

Different parameter values cause qualitatively different problems

Change initial locations for friendly/enemy units

1. Parameterizing

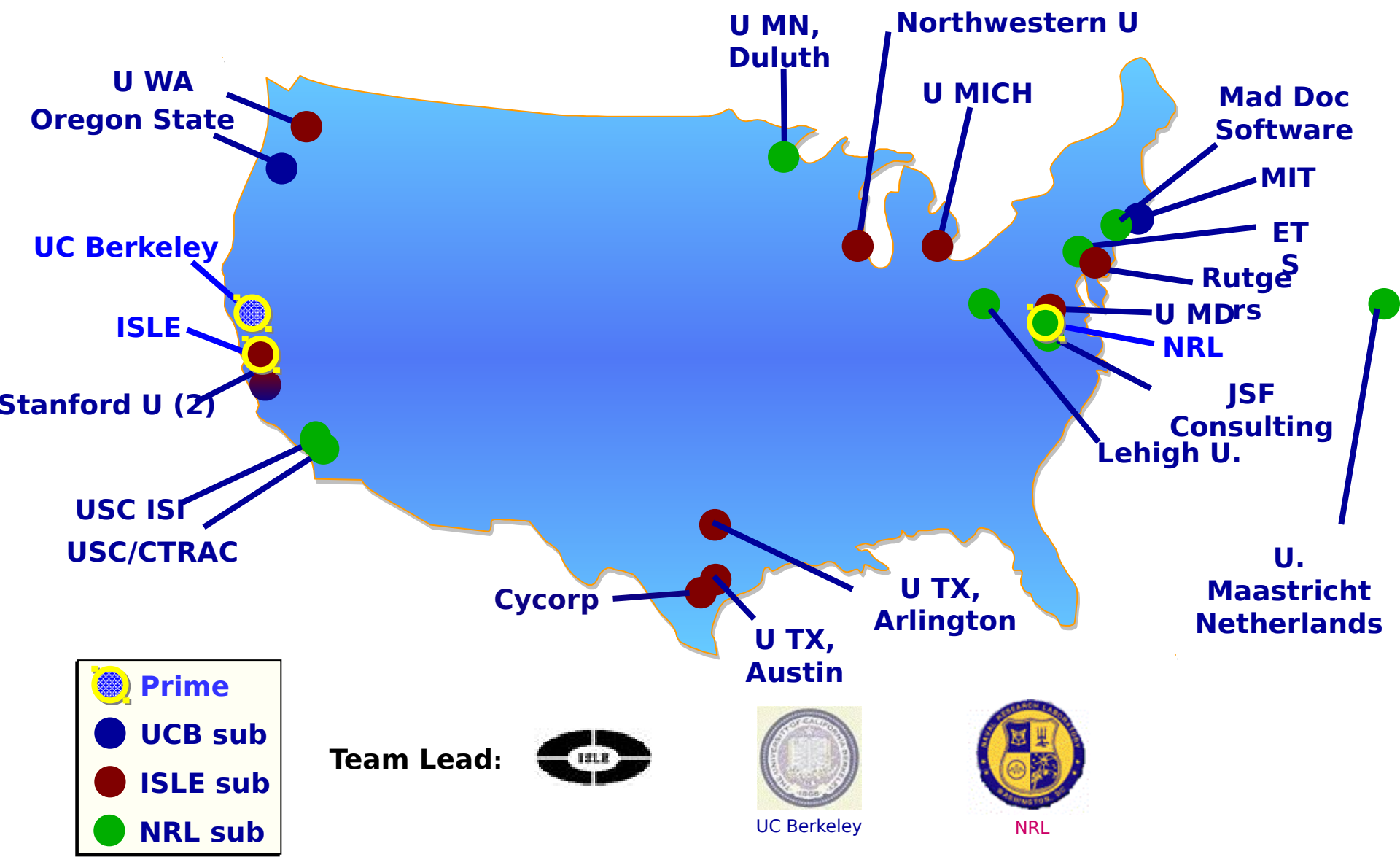
Test on problems with different parameter values

Not transfer

0. Memorizing

Not transfer

Teams & Performers



TL Schedule & Metrics

